Delivering real carbon reductions: the role of life cycle assessment in design and engineering

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Abstract

National greenhouse gas emissions reporting frameworks take a "territorial" perspective, reporting on emissions produced within national territories. However, much of what we design, engineer and consume in the UK and other countries is manufactured abroad. The 'embodied carbon' of our imports is not included in national accounts (Figure 1), nor in typical design and engineering processes, and so is traditionally ignored. We can only be sure that our activities are contributing to real, overall carbon reductions if we consider our complete carbon footprint.

To achieve this, designers and engineers can use life cycle assessment (LCA) or related methods to determine the carbon footprint of their products. But this is usually data and time intensive, both of which are in short supply in real design and engineering processes. Our research seeks to solve this problem.

Key messages

1) LCA can be used **retrospectively**, after a design has been produced. At this stage there is more data and hence certainty in predictions of environmental impact, which is useful for accurate reporting, but is often too late to change the design to reduce carbon. (See Box 1.)
2) Using LCA **proactively** within design processes makes it more feasible to inform and influence decisions, but there is then less data available for LCA, and more uncertainty. Rather than using single-point estimates of environmental impacts (as is typical), a probabilistic approach can help. This can visualise uncertainty in estimates for designers, and raise confidence that design choices will lead to real reductions. (See Box 2.)
3) Among other projects, we are applying both forms of LCA to understand and minimise the environmental impacts of novel bio-based construction practices (Interreg "Circular Biobased Construction Industry"; CBCI)
4) Quantifying the climate impact of bio-based materials remains a challenge in both academia and industry and is crucial for achieving net zero. We and colleagues are working on this; see 'further information'.

Further information:

- CBCI project: https://www.bath.ac.uk/projects/cbci-circular-bio-based-construction-industry/
- Allen, S. New research grant with industrial partners: LCA in design of net-zero carbon buildings, EP/V047027/1
- Hawkins, W., Cooper, S., Allen, S., Roynon, J., & Ibell, T. (In press). Embodied carbon assessment using a dynamic climate model: Case-study comparison of a concrete, steel and timber building structure. *Structures*.

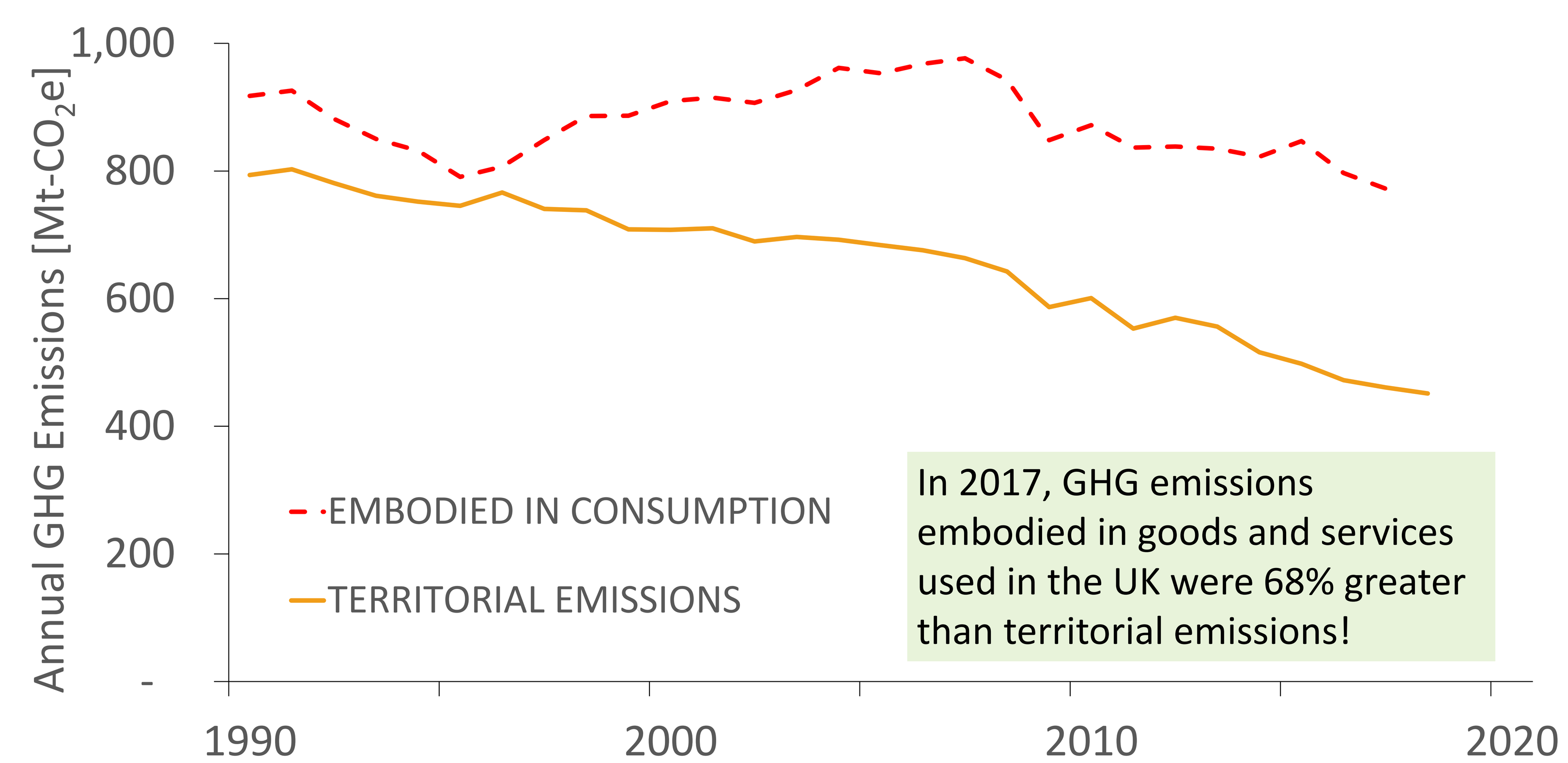

Figure 1. Annual UK greenhouse gas (GHG) emissions

Data sources: UK Carbon footprint data from Defra / University of Leeds; Territorial emissions data from UK National Atmospheric Emissions Inventory.

Box 1. Retrospective use of LCA to identify hotspots

- In the initial design (Figure 2), LCA found that sheeting, connectors and cladding had high global warming potential (GWP).
- Figure 3 shows how changes to the design could address 'hotspot' emissions, reducing GWP by approximately 50% for this case.
- However, in practice, this was done after the design process, which is often too late to make changes to realise the 'all reductions' scenario in Figure 3.

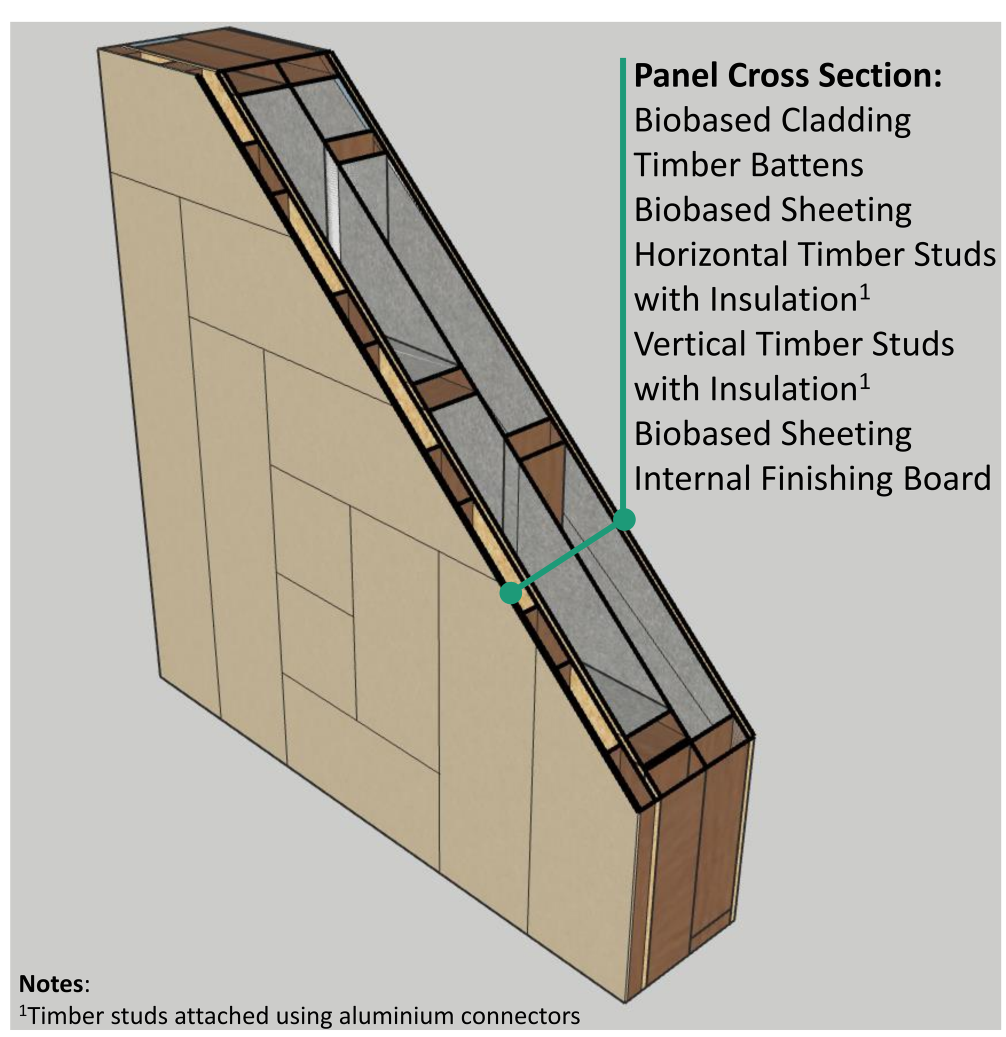

Figure 2. Panel Schematic

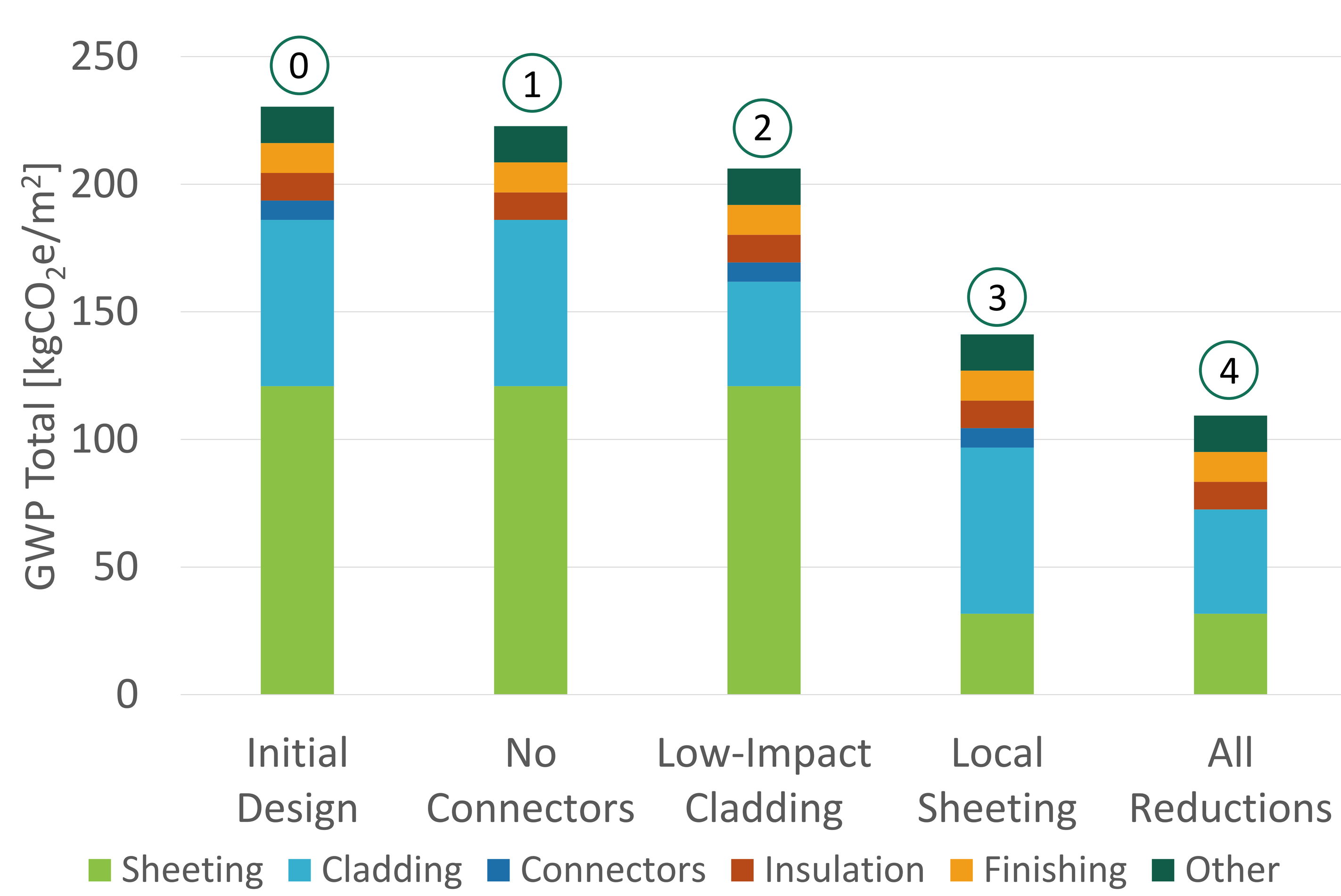

Figure 3. Hotspot analysis and reduction opportunities

Hotspot reduction:
0 Initial Design
1 Connectors removed from panel
2 Cladding replaced with low-impact alternative
3 Sheeting replaced with locally produced product
4 All reduction measures

Further information:

Cascione, V., Roberts, M., Allen, S., Dams, B., Maskell, D. & Shea, A. Life cycle assessment of circular bio-based construction. *4th Int. Conf. on Bio-Based Building Materials.* June 16-18 2021, Barcelona, Spain

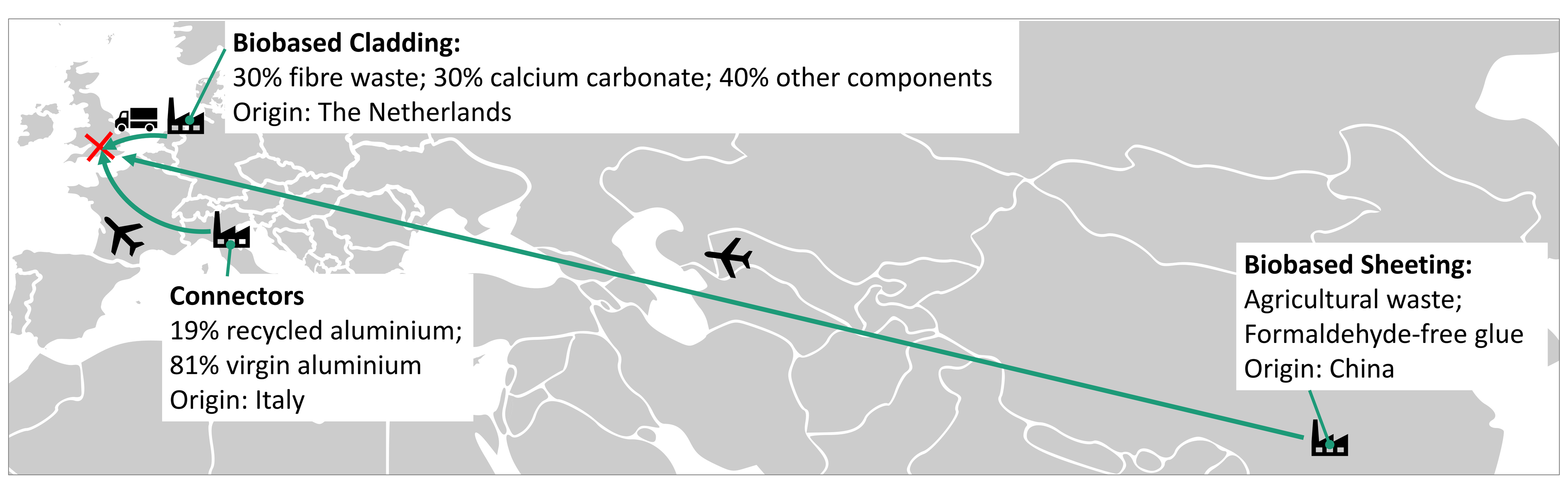

Figure 4. Source locations and transport modes of key components

Box 2. Proactive use of LCA in design process (example for material selection)

- In real design processes both time and data are limited. There is also greater uncertainty about what a design will ultimately look like. This makes LCA challenging.
- It is therefore useful to visualise uncertainty in estimates, as in Figure 5. The distributions are created by applying a data quality assessment to single-value estimates from a standard LCA approach. The negative numbers represent net carbon sequestration in bio-based materials.
- We see that the values for some materials are more certain (have less spread and taller spikes) than others. We can also see that in some cases there is overlap among options, and we see easily that in some cases there are groupings rather than a clear ranking.
- This is more useful for engaging the design team and for increasing confidence that decisions based on LCA results will lead to low-carbon outcomes.

Further information:

Roberts, M., Allen, S., & Coley, D. (2020). Life cycle assessment in the building design process – A systematic literature review. *Building and Environment*, 185(November), 107274. 1

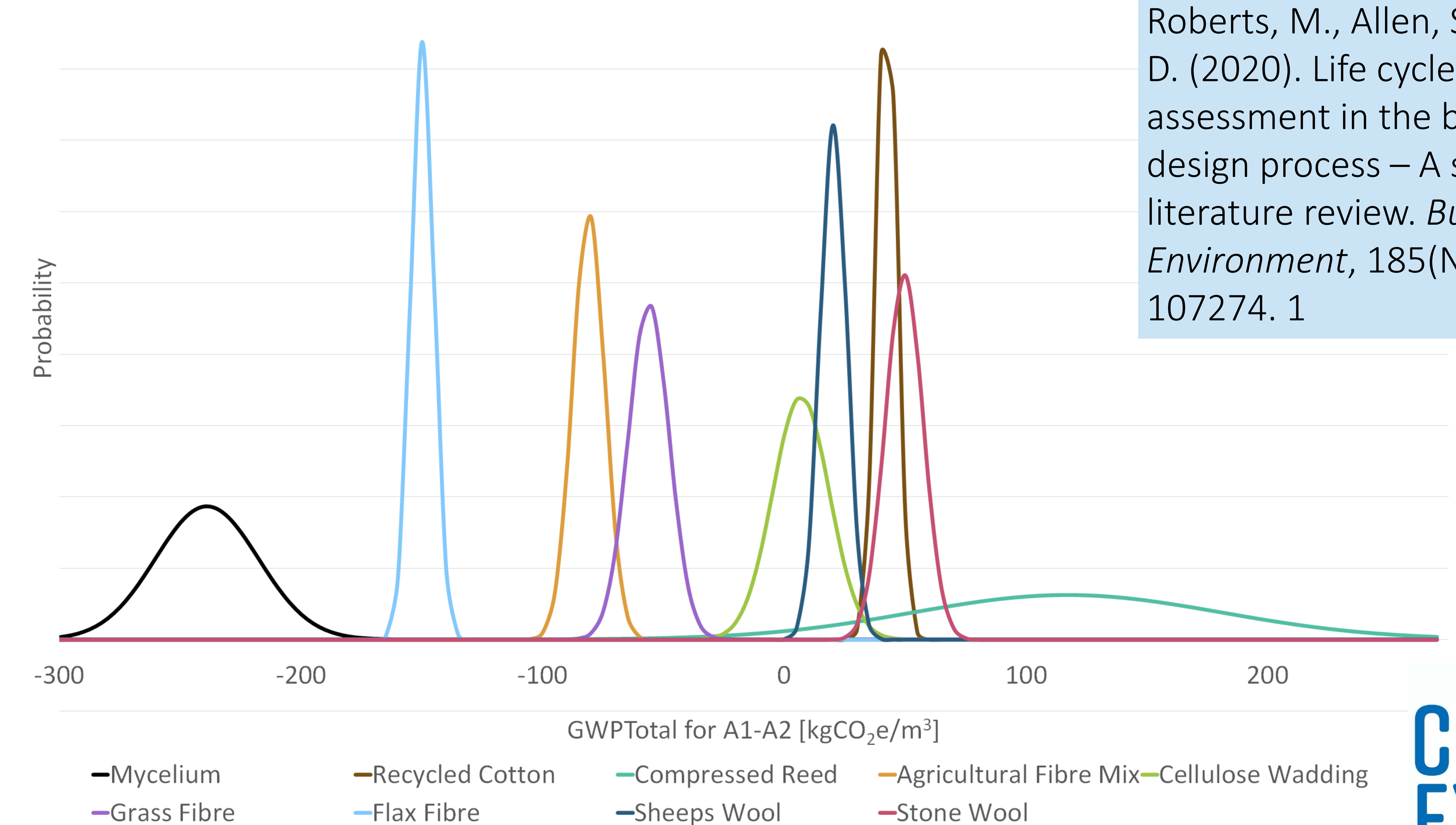

Figure 5. Probabilistic ranges of materials under consideration